

Mössbauer Spectroscopic Study of the Mahadevpur Meteorite Arunachal Pradesh and (Assam)

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ABSTRACT

Mössbauer studies of the Mahadevpur meteorite fell on February 21, 2007 in Arunachal Pradesh and Tinsukia District of Assam, show that the main iron minerals in it are Fe-Ni (Kamacite/taenite), troilite, olivine and pyroxene. These provide characteristic signatures of ordinary chondrites. Mössbauer absorption areas corresponding to different phases favour its classification as H ordinary chondrites.

Keywords: Mössbauer Spectroscopy, Meteorites, Ordinary Chondrites.

INTRODUCTION

Iron bearing minerals & phases from important constituents of a meteorite & provide important clues & their origin or geothermal history, Tripathi *et al.*¹. Initial studies of meteorites revealed that relative distribution of iron bearing minerals show a characteristic pattern for a particular class of meteorite.

Ordinary chondrites are the most common type of meteorites. OC contains appreciable amount of iron in both metallic and silicate form. The metallic iron is present in the form of opaque minerals like

Kamacite, Troilite, etc and the silicates minerals like Olivine and Pyroxene. On the basis of distribution of different amount of metals and different amount of total iron. OC are further divided into three classes i.e. H, L, LL Dodd *et al.*².

Identification and quantitative measurements of minerals are normally made using techniques such as Optical analysis, Inductively Coupled Plasma Mass spectroscopy [ICP-MS], Thermal Ionization Mass Spectrometry [TIMS], Secondary Ion Mass Spectrometry [SIMS], X-ray Diffraction [XRD], Electron Probe Micro Analyzer [EPMA], Instrumental Neutron

Activation Analysis [INAA], Radio Chemical Neutron Activation Analysis [RNAA], Thermo luminescence and Mass Spectroscopic studies.

Since the Mössbauer method has some unique advantages not found in other methods because no pre concentration or chemical treatment steps are necessary and 14.4 KeV γ -rays of ^{57}Fe will be transparent. This method is uniquely sensitive to small amount of iron in large amount of matrix materials as such as meteorites samples. Mössbauer Spectroscopy is highly useful technique to study iron bearing phases in various earth and planetary minerals. Meteorites are very complicated multiphases system where mechanical separation into individual minerals is generally not possible therefore a high quality analysis of iron bearing minerals in meteorites can be done using Mössbauer Spectroscopy. In this study we consider the result of some iron bearing minerals in meteorite sample using Mössbauer Spectroscopy, Kuzmann *et al.*³.

These iron minerals can be easily characterized by ^{57}Fe Mössbauer Spectroscopy, Dunlap⁴, Sprenkel-Segel *et al.*⁵, Burns *et al.*⁶. Many workers have this technique to characterize various iron bearing minerals in variety of meteorites including OC.

EXPERIMENTAL

The fragments were ground to fine powder and about 70mg was sandwiched between two transparent tapes to make one Mössbauer spectrum. The Mössbauer spectra of these powdered samples were recorded at 300K using a conventional constant acceleration Mössbauer

spectrometer with ^{57}Co in Rh matrix as the gamma ray source.

Spectra were computer fitted using a least square routine and assuming each spectrum to be a Lorentzian functions. During the curve fitting the width and the intensity of the two halves of a quadrupole doublet were constrained to be equal. In the case of a sextant line widths of the outer, middle and inner pairs were constrained to be in the ratio 1.2:1.1:1.0. This ratio was chosen on the basis of pure iron spectra. The quality of the fit was judged from the value of χ^2 which was close to 1.0 per degree of freedom. The Isomer Shift (IS) if reports with respect to α -iron. The reported value of IS and quadrupole splitting (QS) have an accuracy of about 0.2mms^{-1} , whereas the hyperfine magnetic field has an accuracy of about 0.2T. The absorption areas have an accuracy of about 5%.

BRIEF DESCRIPTION OF THE METEORITE UNDER STUDY

On 21 February 2007 people in the bordering areas of lohit district of Arunachal Pradesh and Tinsukia District of Assam saw a large fireball in the northern sky at around 9:20 am. Within few seconds the fireball broke apart into several pieces with a Hugh airburst. The shattered fragments of the fireball fell on the earth surface in several places in that area. The meteorite fragments were reported from Mahadevpur, Gossain Gaon, Kothlaguri, podumoni, Mhaloni, Kopatani, Na Kathalguri and Pengeri of Arunachal Pradesh and Assam. Most of the fragments range from 2 to 5 kg in weight. People who collected the fragments broke them into smaller pieces and distributed among fellow villagers. The present

fragment from which about 10 gm rock sample obtained by Mazumdar et al. was originally weighed around 2.5 kg fell over a residence belonged to Hasin Mech, pierced the roof of the house and got enmeshed in a blanket which was kept in a bag over a bed. This fragment was light grey in colour and porous. The fusion crust is apparent and millimeter in thickness. Chondrules are noticeable with naked eye. Most chondrules are sub millimeter in size; few chondrules are seen to be larger than one millimeter. They named these chondrites as Mahadevpur chondrites. We obtained the small piece of this fragment of meteorite from professor Goswami for Mössbauer spectroscopic.

RESULT AND DISCUSSION

The Mössbauer spectrum of Olivine generally consist of single quadrupole doublet with IS value centred 1.13 mms^{-1} and QS value centred around 3.05 mms^{-1} as it is difficult to resolve two octahedral sites

M1 and M2 site and spectrum well consist of two well separated quadrupole doublets and iron occupies the more distorted M2 site with IS value centred 1.10 mms^{-1} and QS value centered around 2.20 mms^{-1} .

Troilite is a magnetically ordered mineral and shows a six line component in the Mössbauer spectrum, with magnetic hyperfine field of about 316 kOe. The magnetic hyperfine field for kamacite varies slightly with the Ni content but remains close to the pure iron value 330 kOe. For taenite the magnetic hyperfine field is around 311 kOe.

The Mössbauer spectrum of Mahadevpur meteorite at room temperature is shown in figure 1 and figure 2 (A), (B) and (C) is the microphotographs of Mahadevpur meteorite. The Mössbauer parameters are shown in Table 1. From spectrum and table we can see that Mahadevpur meteorite exhibit presence of characteristic minerals like olivine, pyroxene, troilite and kamacite as accepted for Ordinary chondrites.

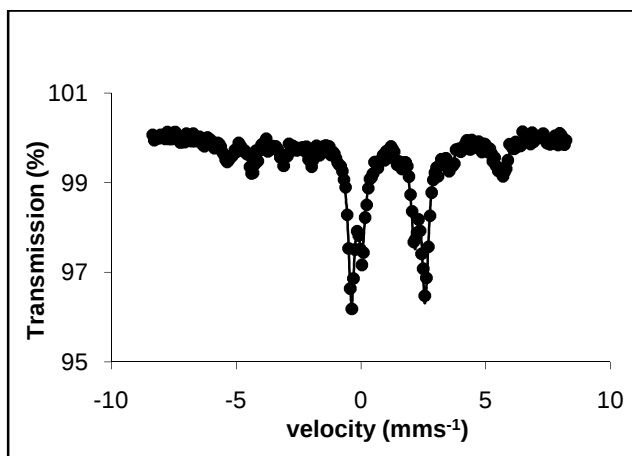


Figure 1 Mössbauer spectrum of the Mahadevpur meteorite at Room Temperature

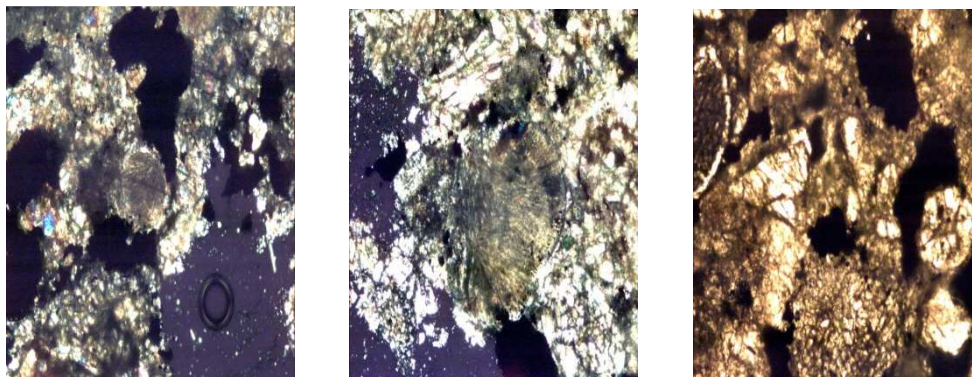


Figure 2 (A, B, C,) Microphotograph of Mahadevpur meteorites

Table 1 Mössbauer parameters of Mahadevpur meteorite

Meteorites	Spectrum	IS (mms^{-1})	QS (mms^{-1})	MHF (kOe)	Area (%)	Assigned Mineral
Mahadevpur	Doublet 1	1.11	2.95	-	37.24	Olivine
	Doublet 2	1.096	2.12	-	25.18	Pyroxene
	Sextet 1	0.81	-0.12	313	17.94	Troilite
	Sextet 2	-0.02	0.21	333	19.6	Kamacite

REFERENCES

1. Tripathi, R. P., Sharma, S.K., Shrivastava, K.L., and Verma, H.C., Mössbauer Spectroscopic Studies of the Piplia Kalan (eucrite) and Lohawat (howardite) Meteorites, *Meteoritics & Planetary Science*, 35, 1, 201-204, (2000).
2. Dodd, R.T., Meteorites: A Petrologic-Chemical Synthesis, Cambridge Univ. Press, Cambridge UK, 368, (1981).
3. Kuzmann, K., Nagy, S., and Vertes, A., Critical Review of Analytical Applications of Mössbauer Spectroscopy Illustrated by Mineralogical & Geological Examples, *Pure Appl. Chem.*, 75, 6, 801-858, (2003).
4. Dunlap, R.A., A Mössbauer Effect Investigation of the Enstatite Chondrite from Abee Canada, *Hyperfine Interaction*, 110, 209-215, (1997).
5. Sprenkel-Segel, E.L., and Hanna, S.S., Mössbauer Analysis of Iron in Stone Meteorites, *Geochimica Cosmochimica Acta*, 28, 1913-1931, (1964).
6. Burns, R.G., and Fisher, D.S., Nanophase Mixed Valence Iron Minerals in Meteorites Identified by Cryogenic Mössbauer Spectroscopy, *Hyperfine Interaction*, 91, 571-576, (1994).